

Evaluation of smear layer removal by EDTAC and sodium hypochlorite with ultrasonic agitation

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Abstract

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Aim To evaluate smear layer removal by different irrigating solutions under ultrasonic agitation.

Methodology Twenty recently extracted mandibular incisors with a single root canal were divided into four equal groups. Three groups were instrumented using the modified double-flared technique, the fourth remained unprepared. Each group was irrigated with either distilled water, 1.0% sodium hypochlorite alone or associated with 15% EDTAC between each file size. The final group was not instrumented but irrigated with 1.0% sodium hypochlorite and 15% EDTAC. A size 15 file energised by ultrasound was used with small amplitude filing movements against the canal walls in all groups. The teeth were split longitudinally and the roots measured to provide three sections of the same size (cervical, middle and apical). Samples were examined under the scanning electron microscope and assessed for the

amount of smear layer by three independent and calibrated examiners. The scoring system ranged from 1 (no smear layer) to 4 (all areas covered by smear layer). Due to the non-parametric nature of the data, Friedman's test was used for statistical analysis.

Results Canal walls were covered with smear layer in the group irrigated with 1% sodium hypochlorite alone and the group irrigated with distilled water. Canals irrigated with 1.0% sodium hypochlorite associated with 15% EDTAC had less smear layer throughout the canal ($P < 0.001$). There were no statistical differences for the amount of smear layer found on the cervical, middle and apical thirds when each group was analysed separately.

Conclusions Under ultrasonic agitation, sodium hypochlorite associated with EDTAC removed the smear layer from root canal walls, whereas irrigation with distilled water or 1.0% sodium hypochlorite alone did not remove smear layer.

Keywords: EDTAC, smear layer, sodium hypochlorite, ultrasound.

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Introduction

Root canal treatment can be summarized as a series of procedures for cleaning, shaping and filling the root canal system. One of the most important procedures during treatment is the chemo-mechanical preparation of the root canal, based on the correct use of instruments and irrigating solutions.

Currently, sodium hypochlorite is used as an irrigant because it combines important properties such as tissue dissolving capability and microbicidal activity (Moorer & Wesselink 1982, Cohen & Burns 1998). Østby (1957) proposed the use of ethylenediamine tetraacetic acid (EDTA) at a neutral pH to promote chelation of calcium in dentine. Seidberg & Schilder (1974) showed the self-limiting action of EDTA, by submitting a known amount of calcium in dentine powder to the solution for different periods of time, and found an equilibrium after 7 h. Hill (1959) added the cationic surfactant Cetavlon® (cetyltrimethylammonium bromide) to an EDTA solution, lowering its surface tension and

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obtaining a bacteriostatic action; this solution is called EDTAC.

The smear layer is composed of organic and inorganic components, which can be removed by association of chelating solutions and sodium hypochlorite (Koskinen *et al.* 1980, Goldman *et al.* 1982, Yamada *et al.* 1983, Sen *et al.* 1995). The use of ultrasound associated with various irrigating solutions contributes to the removal of smear layer (Martin *et al.* 1980, Cheung & Stock 1993, Cameron 1995a, 1995b). Huque *et al.* (1998) reported that ultrasound increased the bactericidal action of 12% sodium hypochlorite, eliminating bacteria even in deep layers of root dentine.

On the other hand, Ciucchi *et al.* (1989) reported that ultrasound in association with 3% sodium hypochlorite did not remove all the smear layer and did not enhance the chelating capability of EDTA. They also observed a decline in the efficiency of the irrigation procedures toward the apical part of canals. Abbott *et al.* (1991) reported that NaOCl associated with EDTAC produced clean canal walls, but ultrasound did not enhance the cleansing action of these solutions.

The purpose of this investigation was to evaluate smear layer removal using sodium hypochlorite associated with EDTAC irrigation and ultrasonic agitation.

Materials and methods

Twenty recently extracted mandibular incisors with a single root canal, and kept in 0.1% thymol solution under refrigeration, were randomly divided into four groups. Standard access to the pulp chambers was performed with diamond burs.

In group 1 (positive control for smear layer), the teeth were instrumented using the modified double-flared technique (Saunders & Saunders 1992) with K-Flex files (Kerr®, Romulus, MI, USA), using 1 mL of distilled water as irrigant between each instrument, to give a total of 10 mL. The irrigating solution was introduced with a plastic syringe and a 30-gauge needle (Accuject, Astra Pharm Products Inc, Westborough, MA, USA). After root canal preparation, a size 15 file energized by ultrasound (Piezon Master 400, EMS Electro Medical Systems, Le Sentier, Switzerland) was introduced 1 mm from the anatomical apex for 1 min, with small amplitude filing movements against the dentinal walls. Distilled water was used as irrigant, with a flow rate of 5 mL min⁻¹.

In group 2, the same instrumentation technique as group 1 was followed, with 1.0% sodium hypochlorite as the irrigating solution, again total volume 10 mL.

Ultrasound was used inside the root canal for 1 min, as described previously, but with 1.0% sodium hypochlorite as the irrigating solution at a flow rate of 5 mL min⁻¹.

Following the same instrumentation technique, 5 mL of 1.0% sodium hypochlorite alternated with 5 mL 15% EDTAC (EDTA with 0.1% Cetavlon®, Sigma Chemical Co., St. Louis, MO, USA) was used for irrigation in group 3. Ultrasound was also used as previously described, 30 s with sodium hypochlorite and 30 s with EDTAC.

Group 4 (negative control for smear layer) was not manually instrumented, but was irrigated with 5 mL of 1.0% sodium hypochlorite and 5 mL of EDTAC. Ultrasound was used, for 30 s with sodium hypochlorite and 30 s with EDTAC.

After instrumentation, all teeth were dried with paper points and split along the long axis in the linguo-buccal direction to expose the entire extent of the root canal. One of the halves was then randomly chosen and submitted to scanning electron microscopy (JEOL 5300 LV, Peabody, MA, USA). Specimens eventually lost during the process were properly replaced by teeth that had undergone an identical treatment regimen.

The length of the root canal was measured and divided equally into cervical, middle and apical thirds, in order to be evaluated separately. After scanning and observing each region with the microscope, an image of the most representative area of that third was taken with 350× magnification. Three pictures were obtained from each tooth, one for each third, to give a total of 60 pictures. The images were then analysed for the amount of smear layer by three previously instructed and calibrated post graduate students. Smear layer was scored as: 1 = no smear layer; 2 = few areas covered by smear layer, with many dentinal tubule openings visible; 3 = most areas covered by smear layer, with few dentinal tubule openings visible; 4 = all areas covered by smear layer, no dentinal tubule openings visible. The assessors were unaware of which group they were analysing.

Due to the non-parametric nature of the sample, statistical analysis was performed using Friedman's test.

Results

The categories of smear layer remaining in each third are reported in Table 1.

There were no differences between groups 1 and 2 (positive control for smear layer and teeth instrumented with only sodium hypochlorite, respectively). Group 3, which was instrumented and irrigated with sodium hypochlorite and EDTAC, was statistically similar to the negative control for smear layer (group 4). Groups 1 and

Table 1 Scores of smear layer remaining in root canals after treatment

	Radicular thirds Treatments		
	Cervical	Middle	Apical
Group 1 (instrumentation + distilled water)	4; 4; 3; 4; 4	3; 3; 3; 4; 4	4; 4; 4; 3; 4
Group 2 (instrumentation + NaOCl 1.0%)	1; 4; 2; 3; 4	1; 4; 1; 4; 4	4; 4; 4; 4; 4
Group 3 (instrumentation + NaOCl 1.0% + EDTAC 15%)	4; 1; 1; 1; 1	1; 2; 3; 1; 1	1; 2; 1; 3; 2
Group 4 (no instrumentation + NaOCl 1.0% + EDTAC 15%)	1; 1; 1; 1; 2	1; 1; 1; 2; 2	1; 1; 1; 1; 3

Scores: 1, no smear layer; 2, few areas covered by smear layer; 3, most areas covered by smear layer; 4, all areas covered by smear layer.

2 were significantly different from groups 3 and 4 ($P < 0.001$). When groups were examined separately, there were no statistical differences between root canal thirds (Table 1, $P > 0.05$), i.e. the amount of smear layer found on cervical, middle and apical thirds was similar for each specific group.

Discussion

One of the greatest challenges of root canal treatment is the complete cleaning of the root canal in order to eliminate pulp remnants, bacteria, smear layer, dentine and other organic material.

Sodium hypochlorite (NaOCl) is the most commonly used irrigant in root canal treatment, and has proven to be an excellent irrigating solution, due to its tissue dissolving capability and microbicidal activity. According to Moorer & Wesselink (1982), the active principle of NaOCl solutions is the amount of undissociated HOCl molecules, which are consumed in the interaction with organic matter. However, its action does not affect inorganic material.

Ethylenediamine tetra-acetic acid complements the action of sodium hypochlorite, by chelating calcium ions in dentine and making instrumentation of the root canal easier, especially in narrow canals. Because it is a chelating agent, EDTA is not dependent on a high hydrogen ion concentration to accomplish decalcification, and is effective at neutral pH (Patterson 1963).

These solutions, however, must be in direct contact with the surfaces for effective action. Due to the small diameter of root canals, it is often difficult for the irrigating solutions to reach the apex of the tooth. Ultrasonically activated files may be a means of reaching the entire length of the root canal with irrigating solutions. According to Walmsley *et al.* (1992), the cleaning ability of such files is assisted by acoustic microstreaming.

In this experiment it was presumed that the low surface tension caused by the cationic surfactant (Cetavlon®) and the agitation caused by the file activated by ultrasound efficiently cleaned the root canal

walls in their entire length, enlarging the lumens of the dentinal tubules. Goldberg & Abramovich (1977) reported that EDTAC may facilitate the action of drugs by increasing dentinal permeability and provide greater adhesion for obturating materials.

In this study, sodium hypochlorite alone did not clean smear layer better than distilled water, proving that irrigation with NaOCl alone is not effective. Baumgartner & Cuenin (1992) also observed that ultrasonically energized NaOCl, even in higher concentrations such as 5.25%, did not remove smear layer from the root canal walls.

Cameron (1995a) reported that irrigation with EDTAC between files during instrumentation and extensive use of ultrasound with 15% EDTAC alternated with 4% NaOCl produced dentinal walls free of smear layer. The present study showed that 15% EDTAC alternated with 1% sodium hypochlorite produced the same results, but with less use of ultrasound and lower NaOCl concentration.

Although significant differences were found regarding treatments, no statistical differences were found between root thirds when groups were examined separately. Goldman *et al.* (1982) observed the same with EDTA during instrumentation with a final flush of 5.25% sodium hypochlorite. Other researchers have reported a greater amount of smear layer found at the apical level of root canals treated with NaOCl and EDTA (Yamada *et al.* 1983) or NaOCl alone (Baumgartner *et al.* 1984).

The lack of differences between root thirds in the same group can be explained by the low surface tension of the solutions provided by the cationic surfactant, as well as the use of ultrasound. Due to the combined action of these two factors, the irrigating solutions probably reached the entire extent of the root canal.

Conclusions

According to the methodology employed, it can be concluded that 1.0% sodium hypochlorite associated with 15% EDTAC is efficient in removing the smear layer from root canal walls. Irrigation with distilled water or 1.0%

sodium hypochlorite alone did not produce root canal walls free of smear layer. When groups were examined separately, there were no statistical differences between the amount of smear layer found on canal walls in the cervical, middle and apical thirds.

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References

- Abbott PV, Heijkoop PS, Cardaci SC, Hume WR, Heithersay GS (1991) An SEM study of the effects of different irrigation sequences and ultrasonics. *International Endodontic Journal* **24**, 308–16.
- Baumgartner JC, Brown CM, Mader CL, Peters DD, Shulman JD (1984) A scanning electron microscopic evaluation of root canal debridement using saline, sodium hypochlorite, and citric acid. *Journal of Endodontics* **10**, 525–31.
- Baumgartner JC, Cuenin PR (1992) Efficacy of several concentrations of sodium hypochlorite for root canal irrigation. *Journal of Endodontics* **18**, 605–12.
- Cameron JA (1995a) The choice of irrigant during hand instrumentation and ultrasonic irrigation of the root canal: a scanning electron microscope study. *Australian Dental Journal* **40**, 85–90.
- Cameron JA (1995b) Factors affecting the clinical efficiency of ultrasonic endodontics – a scanning electron microscopy study. *International Endodontic Journal* **28**, 47–53.
- Cheung GS, Stock CJ (1993) In vitro cleaning ability of root canal irrigants with and without endosonics. *International Endodontic Journal* **26**, 334–43.
- Ciucchi B, Khettabi M, Holz J (1989) The effectiveness of different endodontic irrigation procedures on the removal of the smear layer: a scanning electron microscopic study. *International Endodontic Journal* **22**, 21–8.
- Cohen S, Burns RC (1998) *Pathways of the Pulp*, 7th edn. St. Louis, MO, USA: Mosby.
- Goldberg F, Abramovich A (1977) Analysis of the effect of EDTAC on the dentinal walls of the root canal. *Journal of Endodontics* **3**, 101–5.
- Goldman M, Goldman LB, Cavaleri R, Bogis J, Lin PS (1982) The efficacy of several irrigating solutions for endodontics: a scanning electron microscopic study, part II. *Journal of Endodontics* **8**, 487–92.
- Hill PK (1959) Endodontics. *Journal of Prosthetic Dentistry* **9**, 142.
- Huque J, Kota K, Yamaga M, Iwaku M, Hoshino E (1998) Bacterial eradication from root dentine by ultrasonic irrigation with sodium hypochlorite. *International Endodontic Journal* **31**, 242–50.
- Koskinen KP, Meurman JH, Stenval H (1980) Appearance of chemically treated root canal walls in the scanning electron microscope. *Scandinavian Journal of Dental Research* **88**, 397–405.
- Martin H, Cunningham MJ, Morris JP, Cotton WR (1980) Ultrasonic versus hand filing of dentine: a quantitative study. *Oral Surgery, Oral Medicine and Oral Pathology* **49**, 79–81.
- Moorer W, Wesselink PR (1982) Factors promoting the tissue dissolving capability of sodium hypochlorite. *International Endodontic Journal* **15**, 187–96.
- Østby NB (1957) Chelation in root canal therapy. *Odontologisk Tidsskrift* **65**, 3–11.
- Patterson S (1963) In vivo and in vitro studies of the effect of the disodium salt of ethylenediamine tetra-acetate on human dentine and its endodontic implications. *Oral Surgery, Oral Medicine and Oral Pathology* **16**, 83–103.
- Saunders WP, Saunders EM (1992) Effect of noncutting tipped instruments on the quality of root canal preparation using a modified double-flared technique. *Journal of Endodontics* **1**, 32–6.
- Seidberg BH, Schilder H (1974) An evaluation of EDTA in endodontics. *Oral Surgery, Oral Medicine, Oral Pathology* **37**, 609–20.
- Sen BH, Wesselink PR, Türkün M (1995) The smear layer: a phenomenon in root canal therapy. *International Endodontic Journal* **28**, 141–8.
- Walmsley AD, Laird WR, Lumley PJ (1992) Ultrasound in dentistry – Part II: Periodontology and endodontics. *Journal of Dentistry* **20**, 11–7.
- Yamada RS, Armas A, Goldman M, Lin PS (1983) A scanning electron microscopic comparison of a high volume final flush with several irrigating solutions: part III. *Journal of Endodontics* **9**, 137–42.